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Published in:
Proceedings of EcoDesign 2013 International Symposium

Publication date:
2013

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Abstract
Design for Environment (or ecodesign) has become increasingly important in the aircraft industry. Embraer, one of the world's leading aircraft manufacturers, is committed to improve the environmental performance of the developed aircrafts. The roadmap for the strategic implementation of DfE at Embraer, developed based on the application of the Ecodesign Maturity Model (EcoM2), is presented and further discussed in this paper. The paper describes the main projects and activities carried out at the company so to develop robust processes for the development of products with a better environmental performance.

Keywords:
Ecodesign management, strategic implementation, aerospace sector, Ecodesign Maturity Model

1 INTRODUCTION

Design for environment (DfE) or ecodesign is defined as an environmental proactive management approach for the development of products with a better environmental performance by means of the integration of environmental considerations into the product development process [1,2].

DfE is a concept widely applied and consolidated in several industries, such as the electro electronics industry [3-5]. Over the last years, DfE is also becoming increasingly important in the aircraft industry [6-8]. The main drivers for DfE implementation in the aircraft industry are increased customers' requirements, strict regulations and certification standards, besides the exploitation of new business opportunities.

Over the last years, several agreements have been signed by the main stakeholders and players of the aircraft industry, aiming to minimize the environmental impacts of aviation. During the 6th Aviation and Environment Summit, held in Geneva in 2012, for instance, an agreement towards sustainable aviation was signed by the fifteen major players of the aircraft industry, including Embraer [9].

Embraer is one of the world's leading aircraft manufacturers, operating in the commercial aviation, executive jets, defense and security and agricultural aviation. Throughout its 40-year history, the company has been involved in the design, development, manufacturing, sales and technical support for commercial, agricultural and executive aviation, offering also integrated solutions for defense and security [10].

The implementation of DfE is an integral part of the sustainability strategy of Embraer, which also embraces other areas such as improved manufacturing process, supply chain management and positive society impact. The aim of the DfE project is to integrate the environmental issues into the conception and development of new aircrafts in the context of the Integrated Product Development (DIP). The project is named after DIPAS (acronym for Environmentally Sustainable Integrated Product Development).

In this paper, the roadmap for the strategic implementation of DfE at Embraer, in the context of the DIPAS project, is presented. Section 2 describes the methodology followed by Embraer to develop the strategic roadmap for DfE implementation, which is described in section 3. Section 4 presents a summary and future activities planned.

2 METHODOLOGY

The roadmap for the strategic implementation of DfE at Embraer, which comprises the main projects and activities to be carried out at the company so to develop products with a better environmental performance, was developed in the context of the application of the Ecodesign Maturity Model (EcoM2).

The EcoM2 is a management framework that aims to support managers of manufacturing companies on ecodesign implementation and management, considering the existing best practices, the path to be followed for ecodesign implementation and the strategic drivers of the companies [11].

Based on the EcoM2 diagnosis of the current maturity profile of Embraer's product development regarding ecodesign implementation (which involved documental analysis of PDP-related documents and interviews with several employees from different areas and hierarchical levels in the organization), the current maturity profile of the company was built and represented in a radar that allowed the identification of strengths and improvement opportunities.

Grounded on these results and on the internal drivers of Embraer, the EcoM2 proposed the most suitable ecodesign best practices and improvement projects to be applied, by

adopting a continuous improvement approach for process improvement.

Subsequently, the projects were analyzed and prioritized using the best practices of Embraer for portfolio management, culminating in the development of the Embraer's strategic roadmap for DfE implementation, as presented in Section 3.

3 STRATEGIC IMPLEMENTATION OF DESIGN FOR ENVIRONMENT AT EMBRAER S/A

The application of the EcoM2 at Embraer resulted in a proposition of a set of eight improvement projects for DfE implementation. The proposed improvement projects are:

- Project 1: Get knowledge on DfE and disseminate among all relevant employees: the goal is to establish a structured process to gather knowledge on DfE, DfE practices and tools in order to create the basis for application at the company. Moreover, a process to provide training to the different functions involved in the product development and related processes must be developed, clarifying the potential benefits for the company with ecodesign adoption;
- Project 2: Gather information about legal issues and standards related to the environmental performance of products: the goal is to create a controlled process (to be performed periodically) to obtain and analyze environmental product-related legislation, directives and standards in the countries that the company operates. Additionally, in order to ensure compliance, the creation and continuous updating of mandatory rules to be followed in every development project are suggested;
- Project 3: Perform benchmarking studies in ecodesign to understand what competitors are doing: the goal is to create a controlled process (to be performed periodically) that enables the benchmarking analysis of the competitors' practices, programs and products in relation to ecodesign, in order to drive the internal activities;
- Project 4: Analyze trends and drivers for DfE adoption: this aims to establish a controlled internal process (to be performed periodically) to clearly define which are the internal and external drivers for the development of products with a better environmental performance at the company. The drivers must be communicated to the relevant employees, so to increase awareness. Additionally, a process to identify customers' and stakeholders' requirements in relation to the environmental performance of products and to assess the technological and market trends in this regards should be established;
- Project 5: Establish a DfE program at the company: the goal of this project includes the establishment of a DfE program at the company which will be responsible for ensuring commitment and resources for conducting the activities related to DfE, involving the relevant people, the deployment of responsibilities for the consideration of the environmental issues, communication of achievements, etc;
- Project 6: Deploy the environmental policy of the company for products: the goal is to create a structured and controlled process to perform the deployment and maintenance of an environmental policy for products, based on the environmental policy/strategy of the company. Moreover, the communication of this strategy to the employees involved in the product development and related processes should be ensured;
- Project 7: Assess the environmental impact of a reference product: the goal is to evaluate the environmental impacts of a reference product in order to identify the product life cycle phases and environmental aspects with higher importance in the total environmental impact of the product. Additionally, the life cycle thinking should be implemented at the company;
- Project 8: Perform pilot projects on the application of DfE: the goal is to perform pilot projects at the company in order to start learning in practice how DfE can be considered during the product development and related processes and the real benefits the company can obtain with its application. The projects can include optimizations in the production process, in packaging and distribution or the use of new technologies, for example.

Each project contains the description of the management practices, operational practices and tools and techniques that can support the DfE implementation at Embraer [11].

Based on a portfolio management of those projects, which considered strategic drivers and available resources, a strategic roadmap for implementation of DfE was developed. The roadmap represents the realization of the aforementioned projects in a 5-year timeline, linking interrelated activities through five layers:

1) Strategic implementation of DfE;
2) Measurement by key performance indicators (KPIs) and monitoring;
3) Product development process improvement;
4) Product improvement;
5) DfE methods and tools; and
6) Competences and skills.

The aforementioned projects suggested by the EcoM2 are detailed in activities and placed in the roadmap layers structure. The main activities of the strategic layer includes, for example, the realization of project 4 (analysis of trends and drivers for DfE adoption) and project 6 (deployment of the environmental policy of the company for products).

Embraer counts with an interdisciplinary and multidisciplinary team for the implementation of DfE. Besides the existence of a group of people exclusively allocated to the DfE activities, allocated under engineering support, there is also several supplementary employees from correlated functional areas (including manufacturing, organizational sustainability, materials engineering, supply chain management, technology development, etc.) partially allocated to support the project. The ramification has been identified as a best practice, since it allows the effective deployment of the DfE activities in the whole organization.

The projects defined in the roadmap are currently successfully being applied in the company under six main working areas grounded into the Embraer's environmental policy and strategy:

I. Integration into current business processes: this working area includes:
   a. integration of DfE into the existing programs for development of new aircrafts,
   b. integration of environmental criteria into the evolution program of the engineering cells[1],
   c. product-related environmental legal compliance program,
   d. Integration of DfE into the product development and related processes; and
   e. Interface management with the other areas of the company, such as technological development;

II. Development and implementation of DfE tools: this working area comprises the selection, customization and development of methods and tools that can support the DfE implementation into the current business processes. Examples of developed and implemented methods and tools are:
   a. DfE methodology for pilot project in the evolution of the lean engineering cells;
   b. DfE Guide with more than 600 operational practices and examples from the aerospace industry,
   c. Benchmarking in DfE; and
   d. Simplified-LCA (life cycle assessment) method to evaluate the environmental performance of the products;

III. Monitoring of the results: this working area comprises the selection, customization and development of key performance indicators (KPIs) for measuring the improvement of the DfE consideration into the product development process and in the improvement of the environmental performance of the developed products. It comprises leading and lagging indicators in combination.

IV. Internal and external communication: this working area is responsible for defining and implementing the communication plan internally in the company, considering the different needs of diverse stakeholders, and also external communication to customers, society, governmental agencies, regulatory agencies, etc.

V. Capacitation of relevant employees: this working area is responsible for the capacitation of the employees in the integration of the environmental issues into their day-to-day activities – it comprises the performance of awareness raising lectures, hands-on workshops on DfE, life cycle thinking and developed tools, online trainings, and also external trainings from worldwide well-known DfE experts;

VI. External collaboration: this work area comprises the establishment of partnerships with universities, research centers and other companies involved in the DfE implementation, so to share best practices and experiences on the field. One example of the activities under the external collaboration working area is the organization of the DfE Seminar early this year in São Paulo. The event was developed in collaboration with the Brazilian Industry Confederation (CNI) and the Aeronautics Technological Institute (ITA), with the involvement of several companies and international references in the field.

Several economic, social and environmental benefits have already been accomplished and measured at the company as a result of the implementation of Design for Environment. Embraer sees the DfE implementation as one of the key areas in the future to ensure increased competitiveness in the aerospace sector.

4 SUMMARY

This paper presented the approach followed by Embraer S/A, one of the world's leading aircraft manufacturers, for the strategic implementation of design for environment in the company's product development and related processes.

[1] Embraer follows a lean culture for product development.

Based on the EcoM2 diagnosis of the current maturity profile of Embraer on ecodesign implementation, several improvement projects were identified, prioritized in a strategic roadmap and subsequently implemented in the aforementioned described working areas.

The application of the EcoM2 enabled Embraer to identify the strengths and weaknesses concerning the application of DfE practices, to prioritize the actions and projects to be implemented following a step-by-step approach and to develop a roadmap for the integration of DfE improvement towards environmental sustainability. Furthermore, it provided a common language and a shared vision across the organization for DfE implementation and a framework for the continuous improvement towards higher maturity profiles.

Embraer plans to perform a new assessment of the maturity profile using the EcoM2 in the near future in order to identify the extent of the improvements carried out during the first improvement cycle and to identify new best practices to be implemented in the next improvement cycle towards sustainable aviation.

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